

Satellite Constellations: 2021 Industry Survey and Trends

Erik Kulu

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NewSpace Index

Agenda

- Introduction / NewSpace Index
- Definitions – Which Constellations?
- Statistical Overview of 2021
- Constellations by Applications (Selected)
- Conclusions and Future Work

Introduction / NewSpace Index

- Boom of NewSpace: constellations, launchers, investors!
- NewSpace Index was created in 2016 as a spinoff to Nanosats Database. Divides into:
 1. Commercial Satellite Constellations
 2. Small Satellite Launchers
 3. NewSpace Funding Sources
- Keeping track of: which types, how many and how large constellations are being planned and realized?
- Why? Constellations will have the largest impact on the growth of the space economy. Both as customers and new service providers.

Welcome to

NewSpace Index

Concise original overview of commercial satellite constellations, small satellite rocket launchers and NewSpace funding options. Sister websites www.nanosats.eu and www.factoriesinspace.com



CONSTELLATIONS



SMALL LAUNCHERS



SPACE FUNDING

NewSpace Constellations

Aiming to gather all commercial satellite constellations (megaconstellations). Active, planned and cancelled initiatives included.

Organization	Launched / Planned network	First launch	Form factor	Field	Funding	Technical and comments	Image
Orbcomm (OG2)	50 / 52	1991	Microsat, Smallsat, 3U	IoT / M2M, AIS	Yes	World's first and only commercial satellite network 100% dedicated to M2M. 2 space-as-a-service CubeSats ordered from Clyde Space for 2020	
Globalstar (Second-Generation)	84 / 24	1998	Satellite	Internet, IoT / M2M	Yes	Like "bent-pipes" or mirrors in the sky, the Globalstar satellites pick up signals from over 80% of the Earth's surface.	
AprizeSat	12 / 12	2002	Microsat	IoT / M2M	?	Low-cost satellite data services for monitoring the fuel level, oil and gas pipelines, and mobile tracking of shipping containers, rail cars and trailers.	
SaudiComsat (SaudiComsat)	7 / 24	2004	Microsat	IoT / M2M	-	12 kg satellites for commercial store and forward communication.	
ExactEarth	68 / 67	2008	Hosted, Microsat	AIS	-	9 own microsats called AprizeSat or ExactView. Hosted payloads on 58 Iridium-NEXT satellites and 2 PAZ.	
Planet (RapidEye)	5 / 5	2008	Smallsat	Earth observation	Yes, ?	5 satellites, 5 spectral bands and up to 4-5 million km²/day image capture capacity. 150 kg satellites with 6.5m resolution.	
Ligado (SkyTerra (MBV))	1 / 3	2010	Satellite	5G, IoT / M2M	\$100M+		
SES (O3b / mPOWER)	20 / 70	2013	Satellite	Internet	Yes	Satellites in 8000 km medium earth orbit (MEO) for Internet backhaul. Expanded O3b network would include 24 in high-inclination MEO and 36 in VLEO, plus 10 in current circular equatorial orbit.	
Planet (Flock / Dove / SuperDove)	475 / 150	2013	3U	Earth observation	\$183M	29 MP sensor taking images with 3.7 m ground resolution and swath of 24.6 km x 16.4 km from 475 km altitude.	
Spire (Lemur / Minas)	141 / 150	2013	3U	Weather, AIS, ADS-B, Earthquake (ELF), Constellation-As-A-Service, GNSS Reflectometry, GNSS Radio Occultation, GNSS-RO, GNSS-R	\$150M+	Measure change in GPS signals after passing atmosphere to calculate precise profiles for temperature, pressure, humidity (GNSS-RO). GNSS-R demonstrators launched in Dec 2019 and Jan 2021. Investigating earthquake (ELF) detection?	
Planet (Terra Bella / Skybox)	15 / 24	2013	Smallsat	Earth observation	Yes, ?	Color and near-infrared imagery (90 cm resolution) in 120 kg package. First-ever commercial high-resolution video from a satellite.	
AAC Clyde Space (xSPANCION)	0 / 10	2014	6U	Constellation-As-A-Service, Earth observation	\$22.5M+	Space-as-a-service project where AAC Clyde Space will manufacture 10 and demonstrate at least four in orbit.	
Chang Guang (Jilin-1)	24 / 138	2015	Satellite	Earth observation, Video	\$375M+	Multiple Earth observation satellites with various resolutions and capabilities, some with video or push-broom. About 40 kg each and resolution about up to 1m.	
GHGSat	3 / 10	2016	Microsat	Emissions monitoring	\$55.5M	Measure CO2 and methane in a FoV of ~12 km x 12 km and resolution of <50 m. Sensors include 2D Wide-Angle Fabry-Pérot imaging spectrometer with 15 kg satellite.	
BlackSky	8 / 16	2016	Microsat	Earth observation	\$253.5M	Color imagery at a resolution of 1 meter. With 16 satellites can provide hourly revisit times for most major cities. 50-cm resolution in the future.	

Definition – Which Constellations?

- **Satellite constellation** - Number of similar satellites, of a similar type and function, designed to be in similar, complementary, orbits for a shared purpose, under shared control. Sometimes defined as a set of satellites working together in order to provide a service or a group of satellites with a common purpose. Different from satellite programs and fleets.
- **3 or more spacecraft** - Minimum required for a continuous coverage in geostationary or Molniya orbits. Literature review revealed minimum satellite counts of 2 and official definition has not been found, but 3 appropriately filters out many satellite pairs.
- **Commercial focus** - Primarily owned, financed and managed by commercial entities for the purpose of providing a commercial service. Excluding government, military, academic, scientific and non-profit constellations. Likely to be expanded in the future, because all will have an impact to the space economy including launch and manufacturing services.
- **Announced or launched after 2002** - Filtering out the first-generation constellations for Iridium, Globalstar and Orbcomm as of now, in addition to other projects from the 1990s.
- *Please see paper for all classifications: **Applications, Form Factors, Statues, Orbits, Delays.***

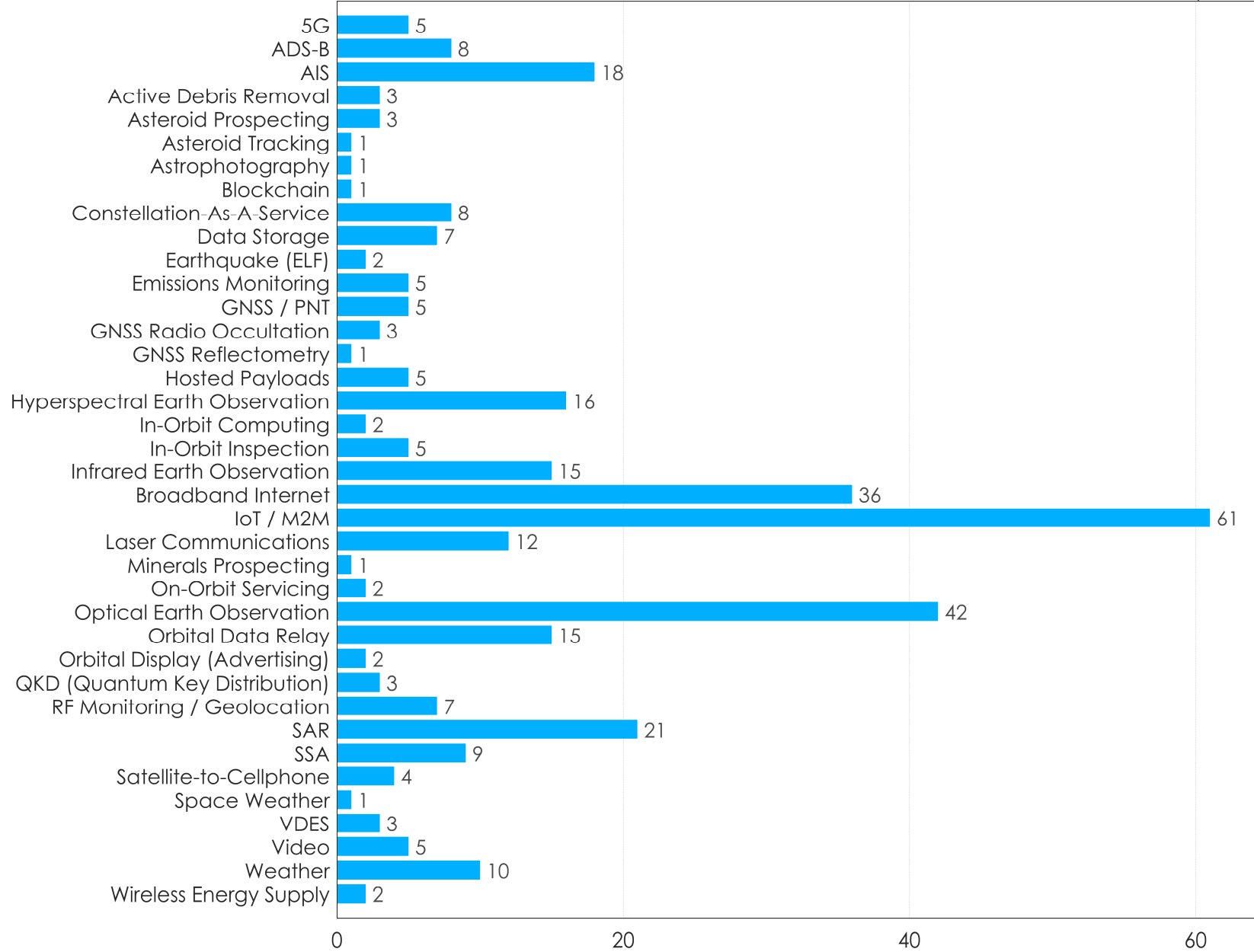
Statistical Overview 2021

251 Commercial Satellite Constellations

Constellations by Applications

2021/06/22

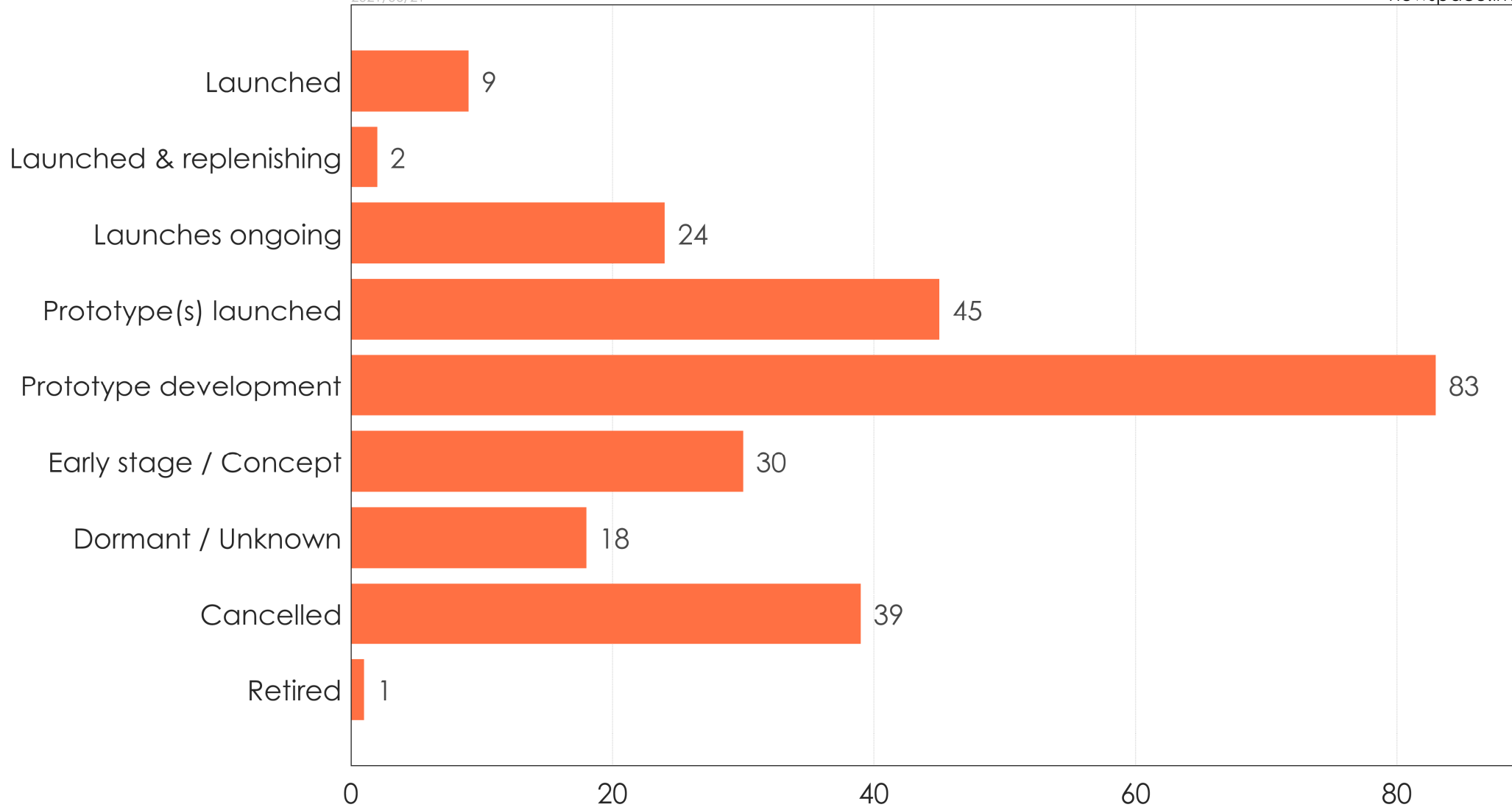
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Constellation Statuses

2021/06/21

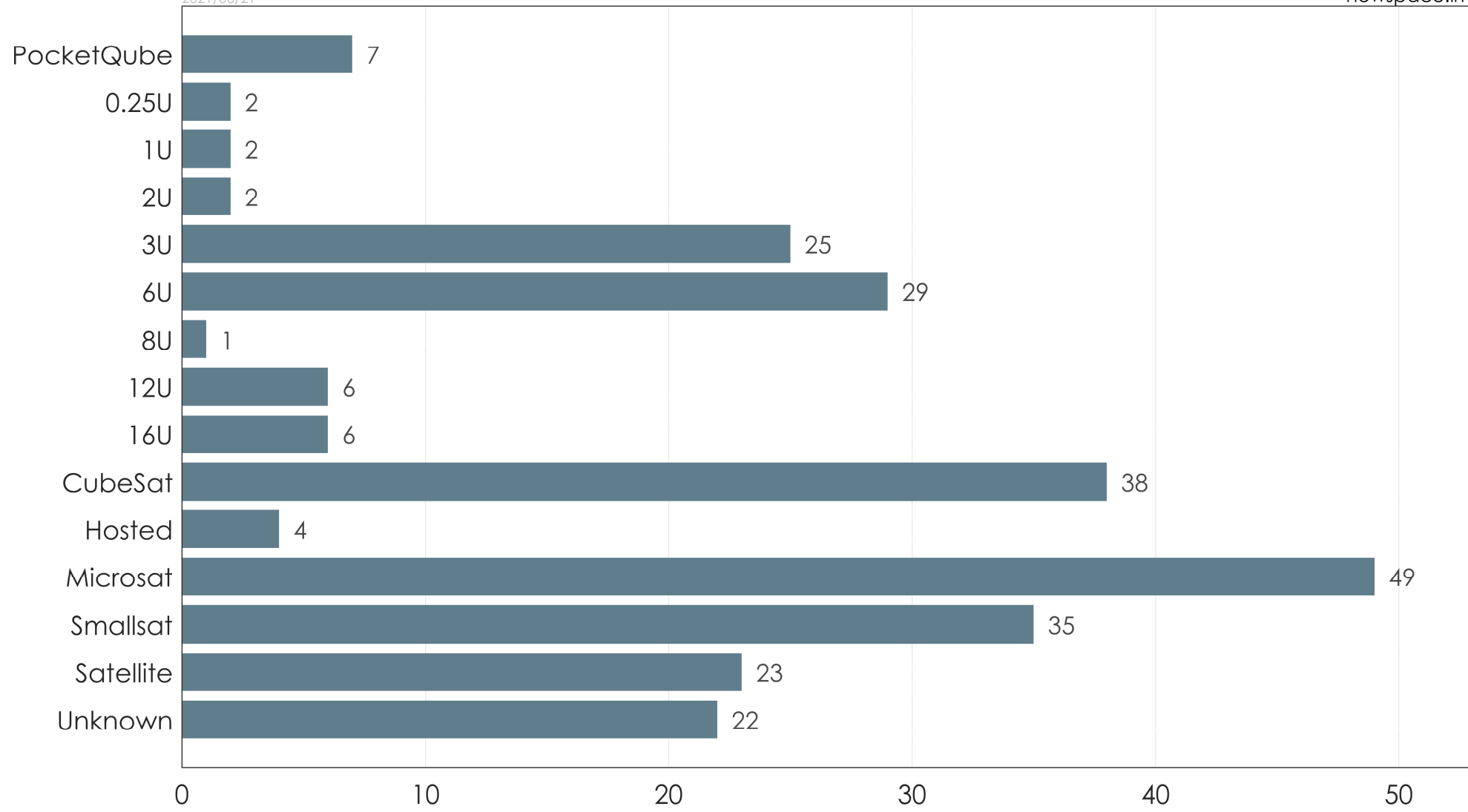
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Constellation Form Factors

2021/06/21

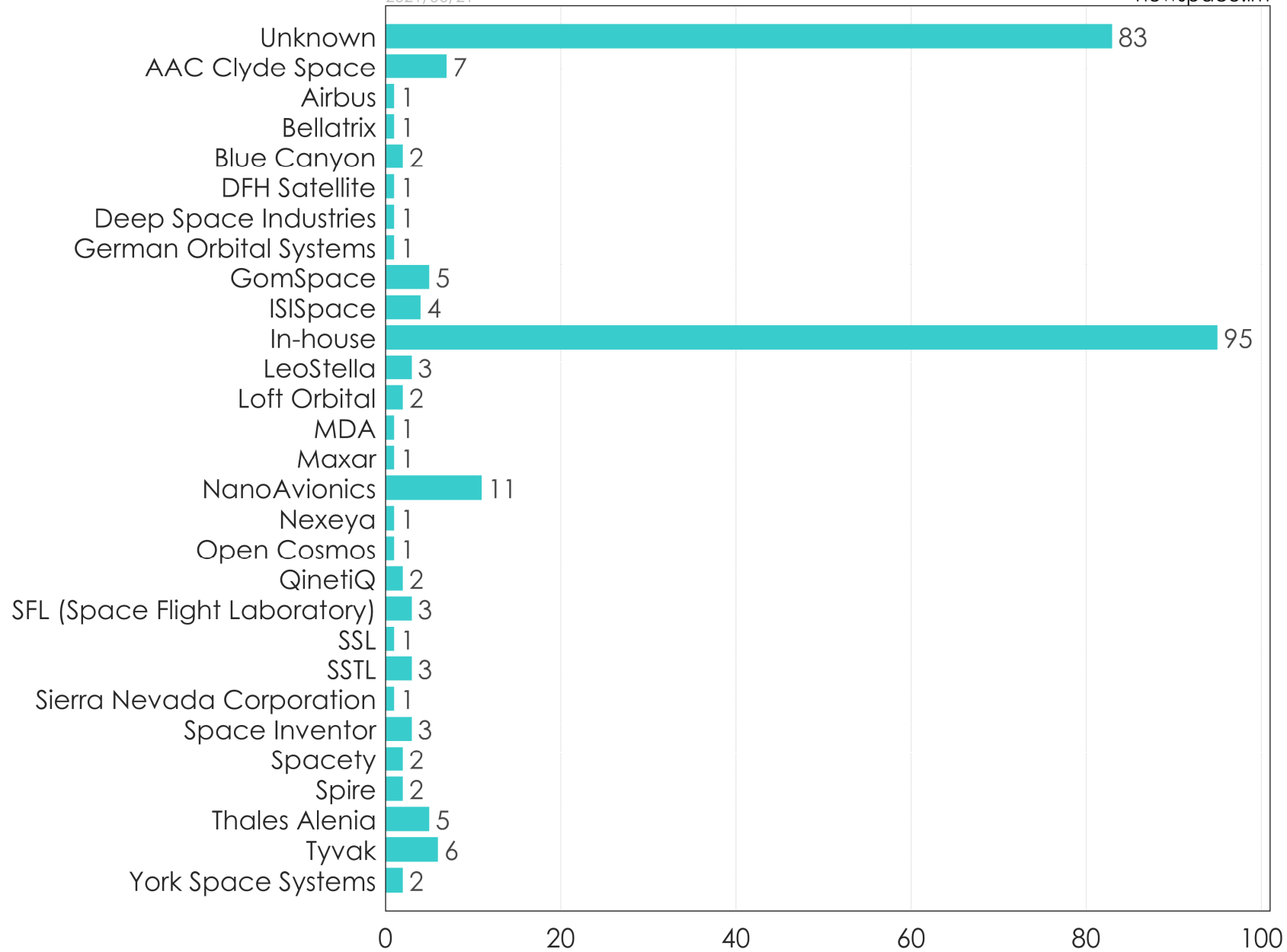
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Constellation Manufacturers

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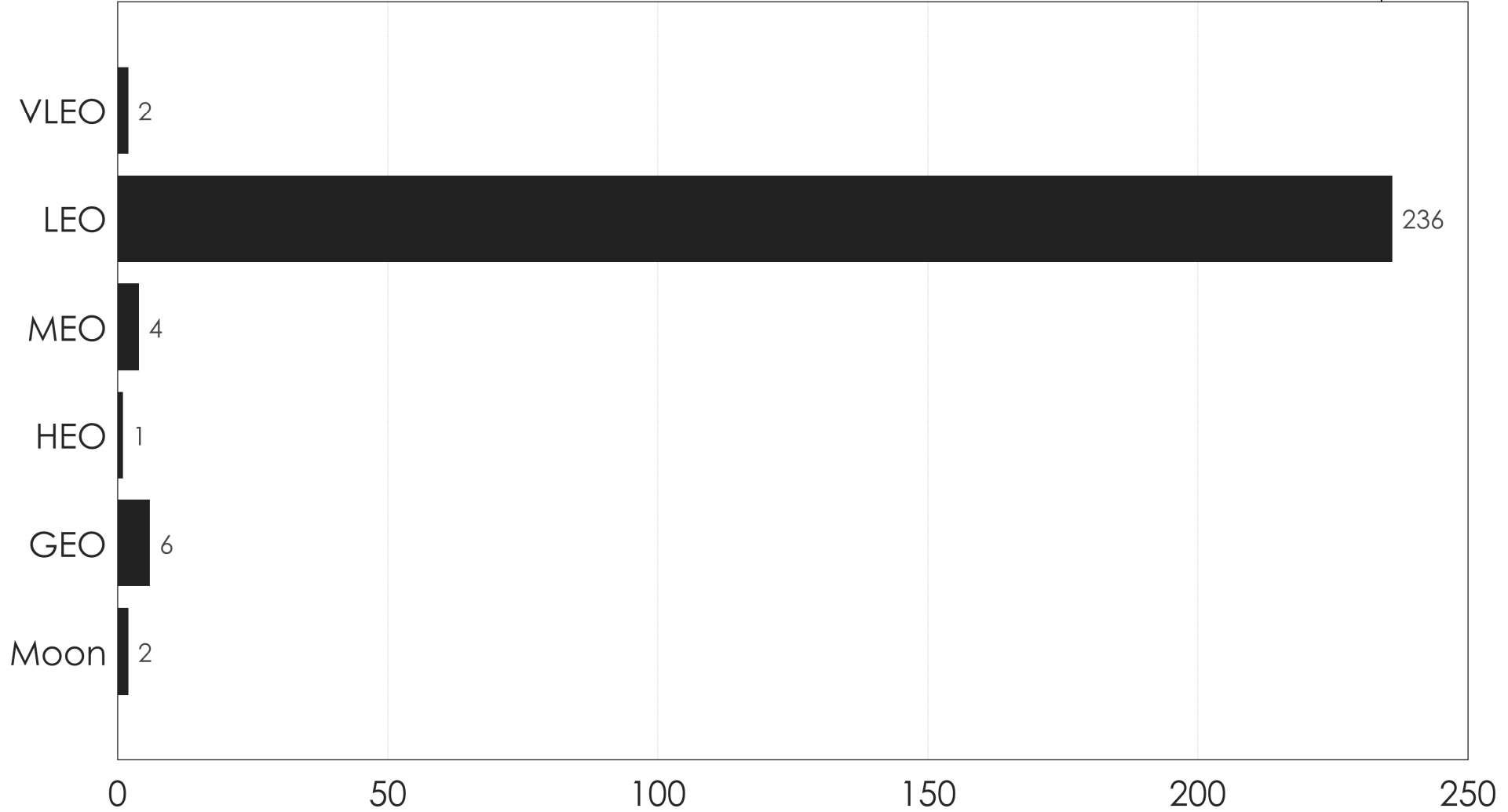
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Constellation Orbits

2021/06/21

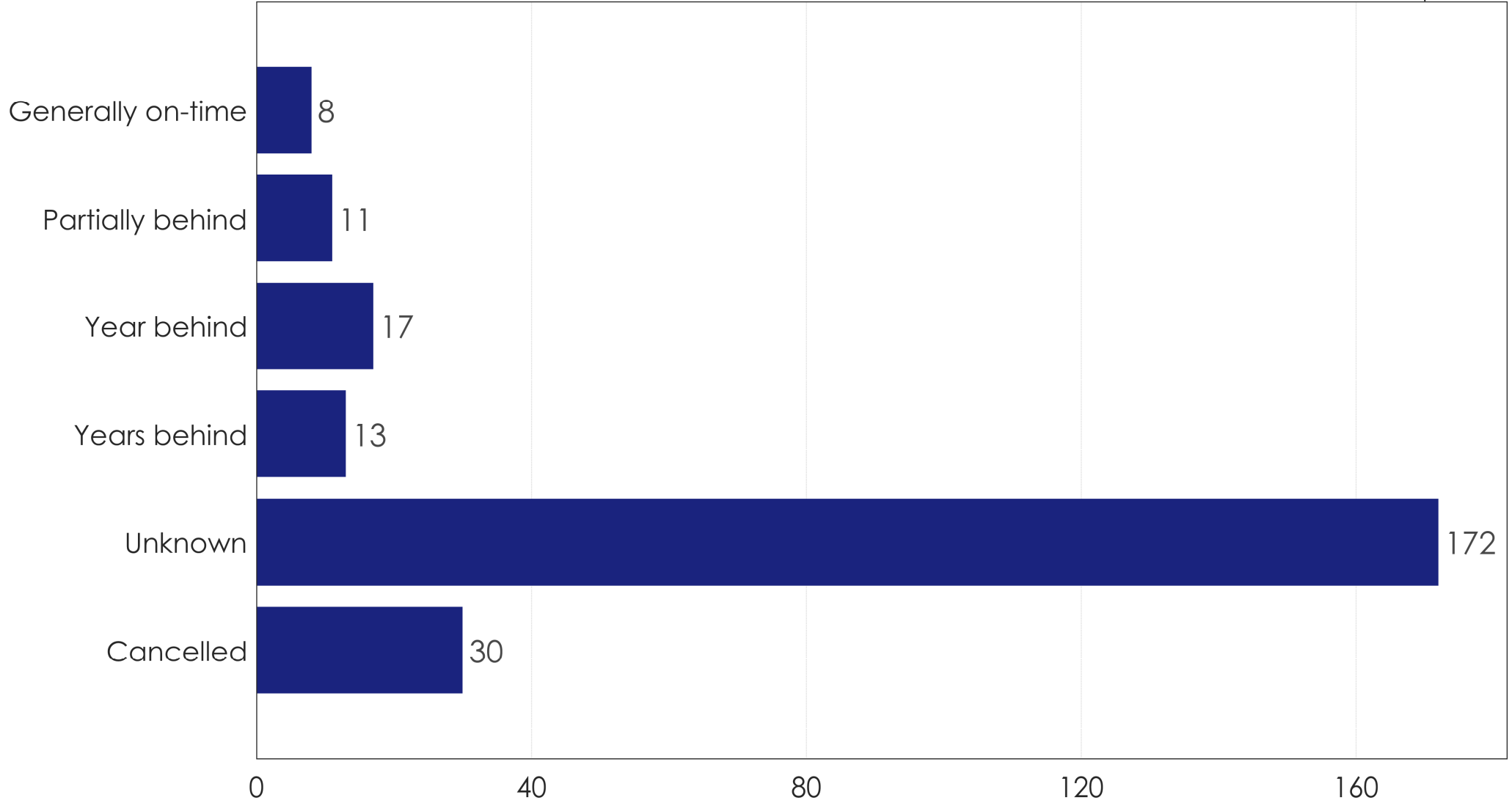
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Constellations Delays

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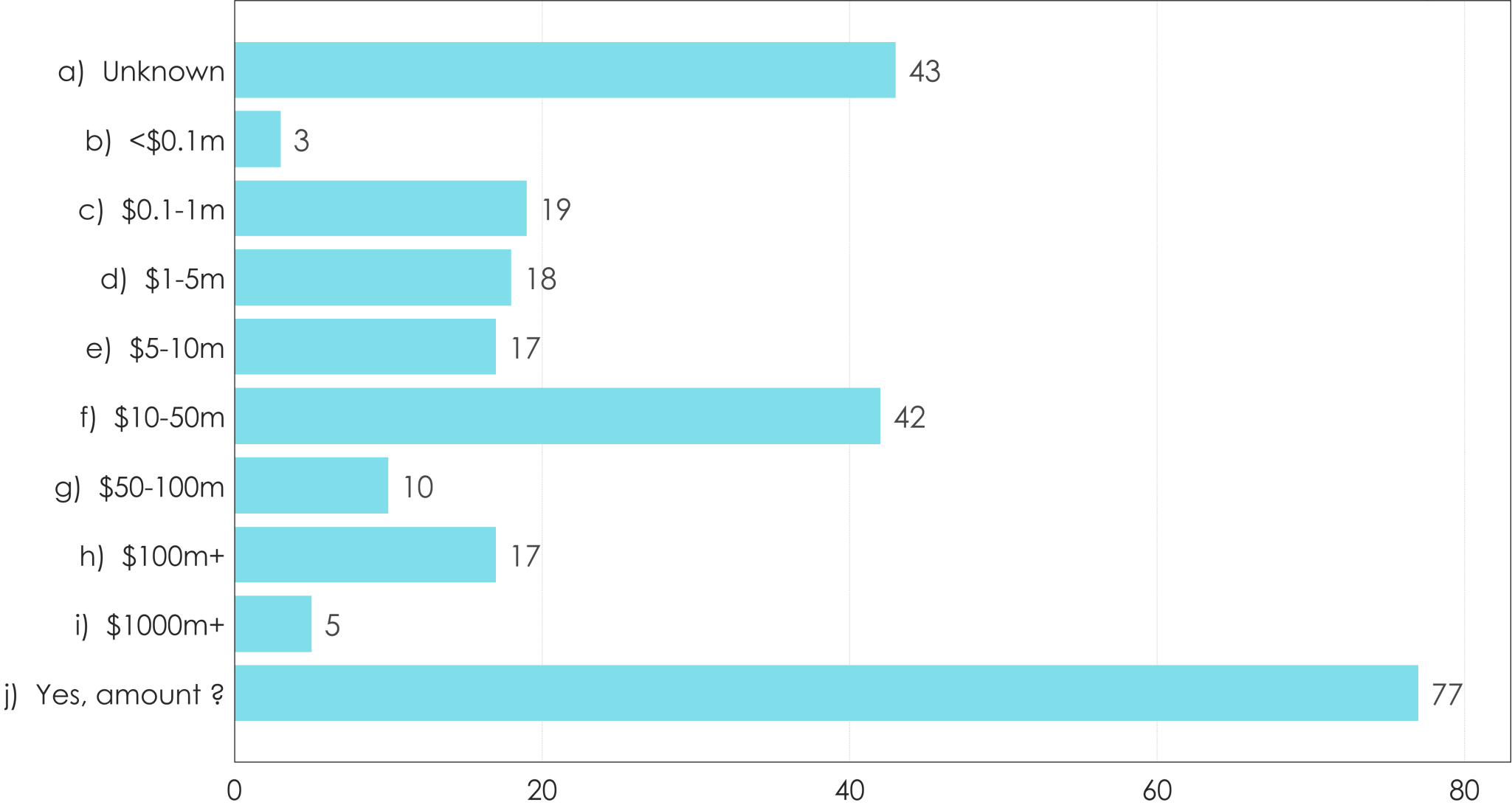
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Constellations Funding

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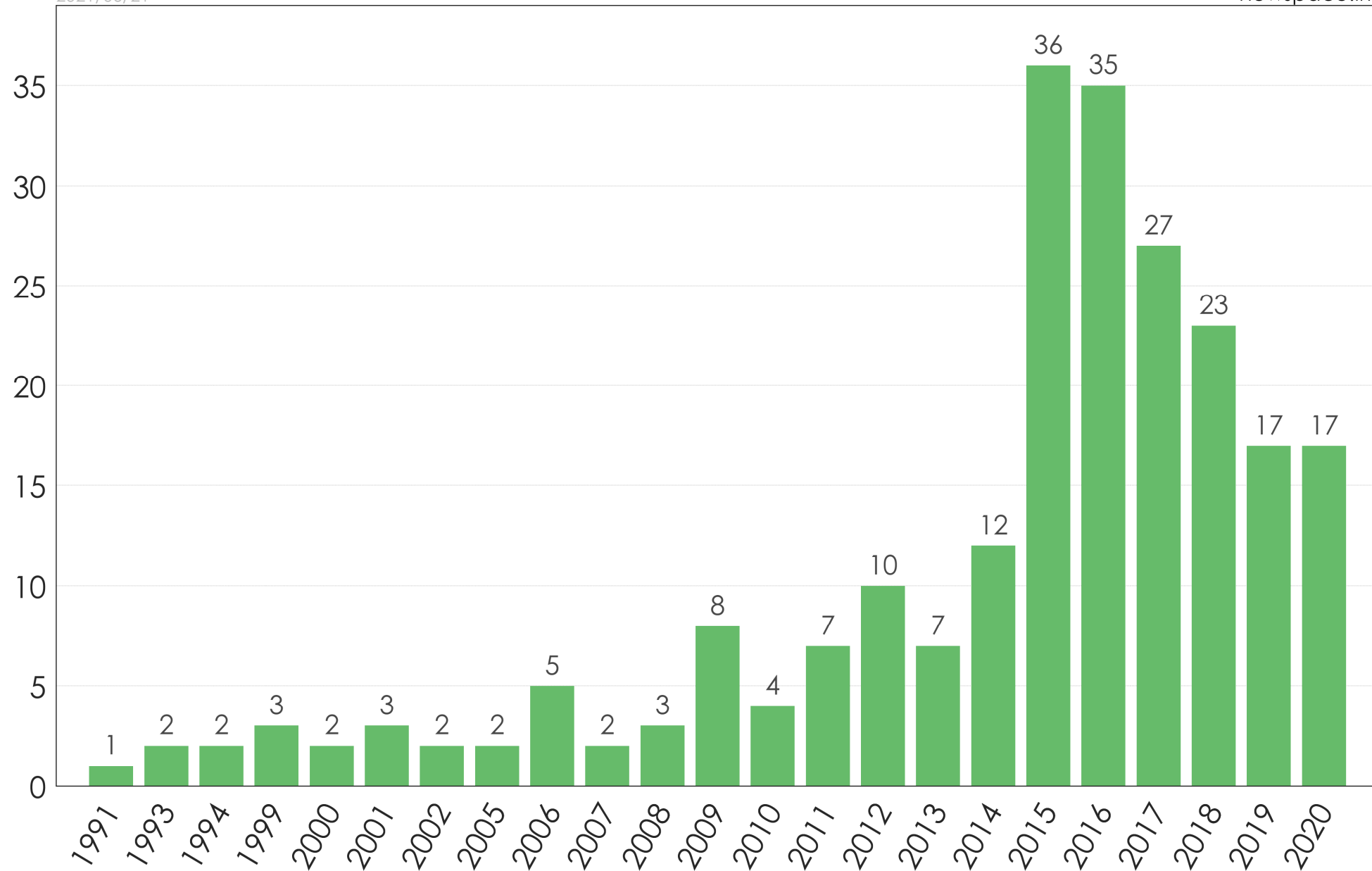
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Constellations Founded

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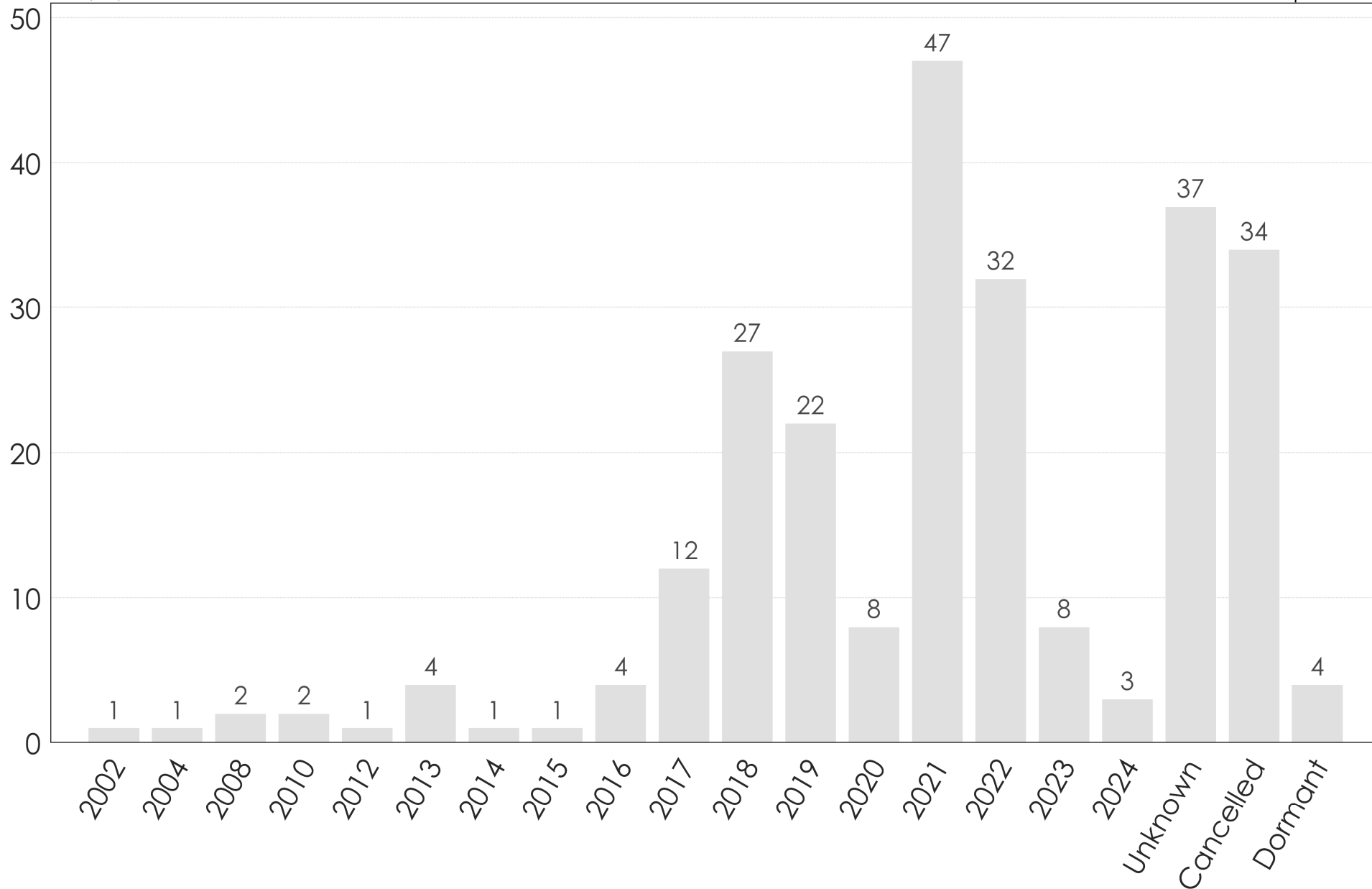
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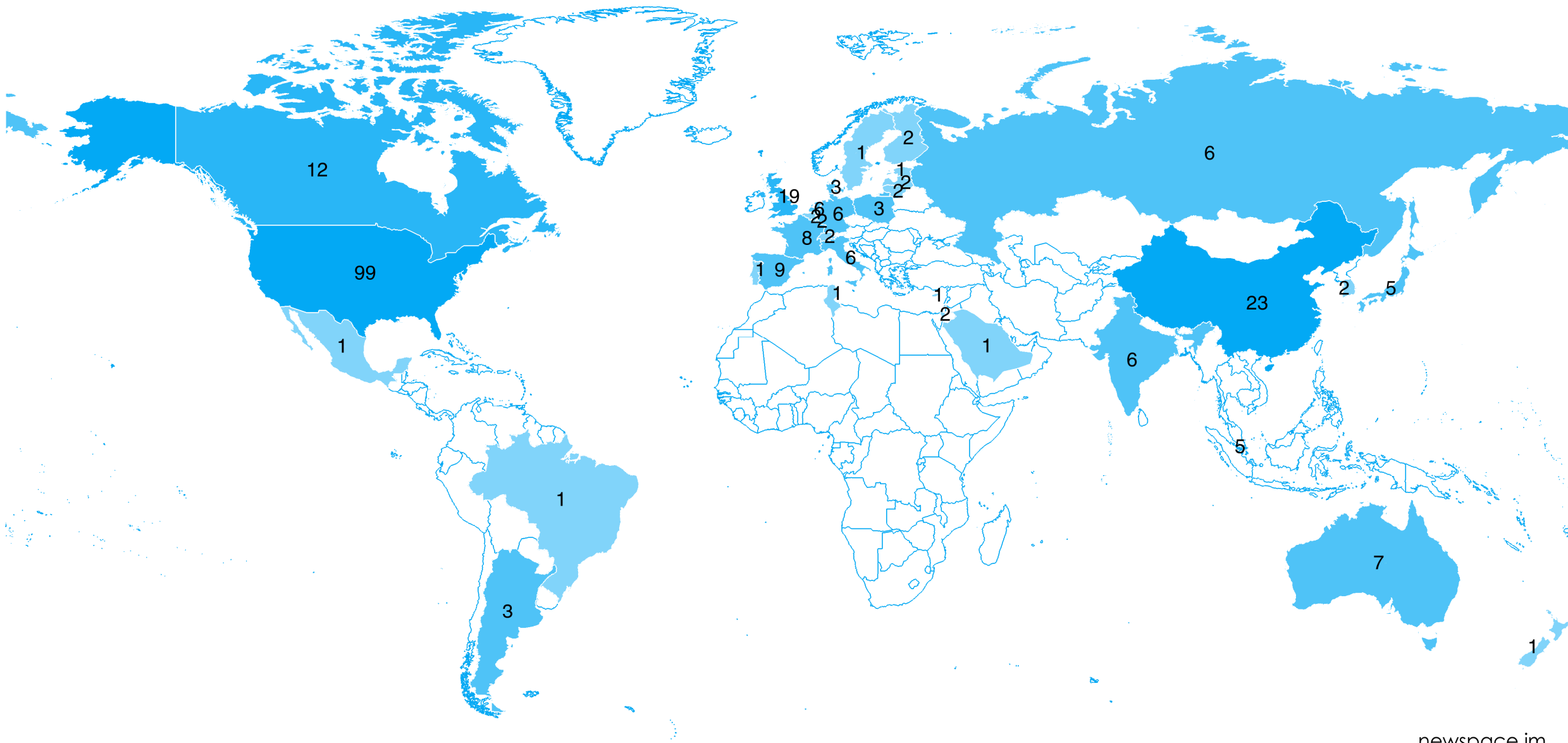
Constellations First Launches

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Constellations Headquarters World Map



Survey by Applications 2021

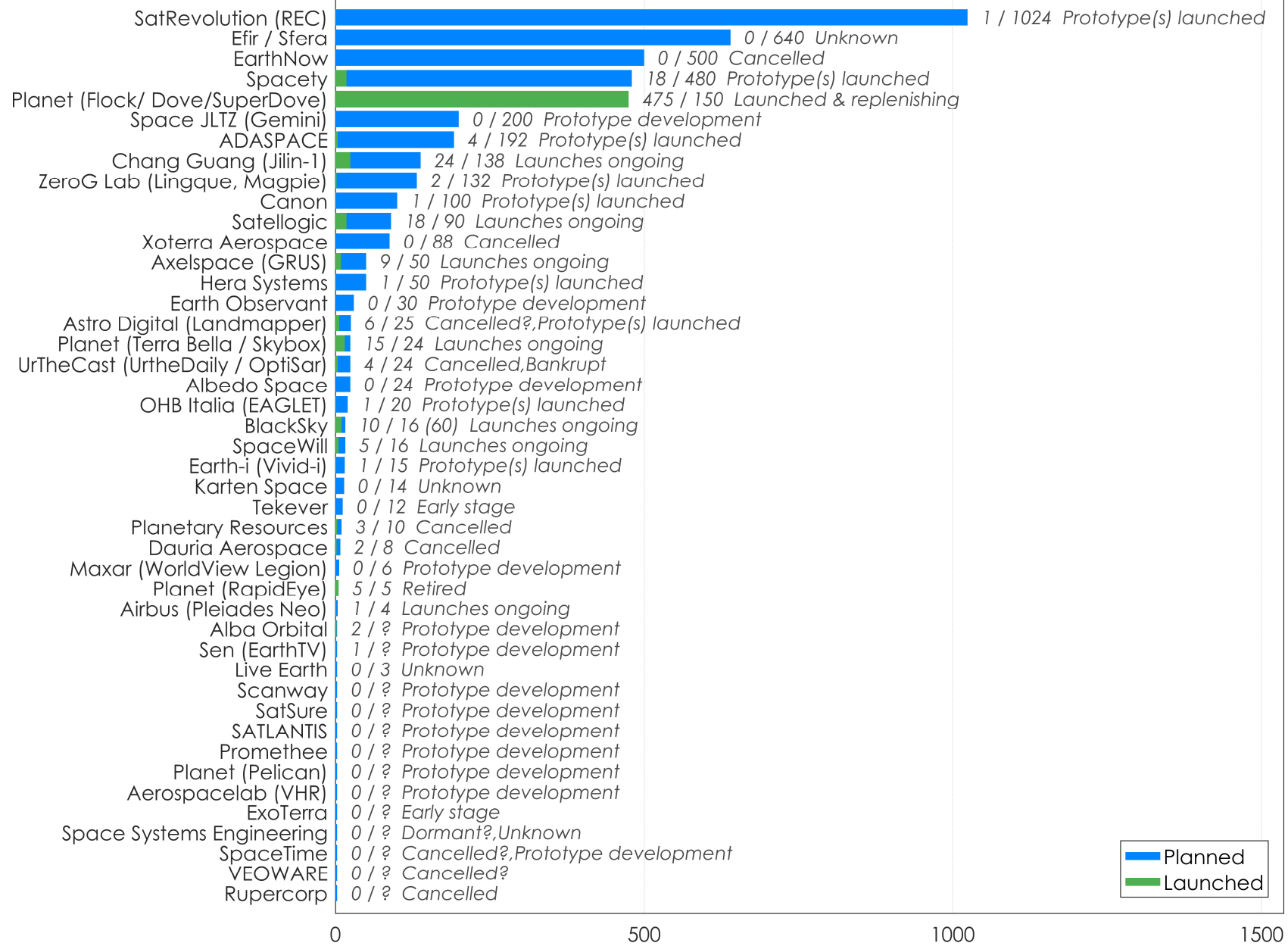
Commercial Satellite Constellations, Selected Applications

Earth Observation, Remote Sensing

Optical Earth Observation Constellations

2021/06/26

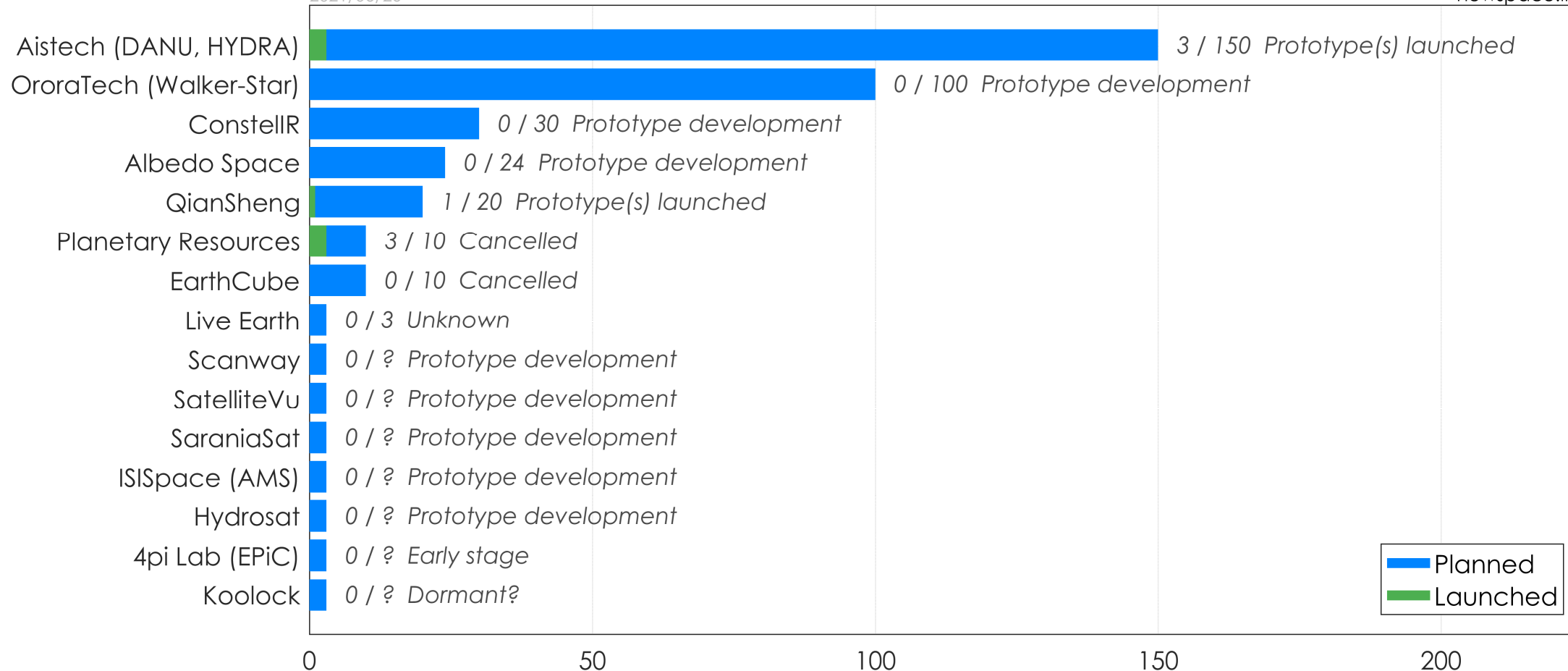
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Infrared Earth Observation Constellations

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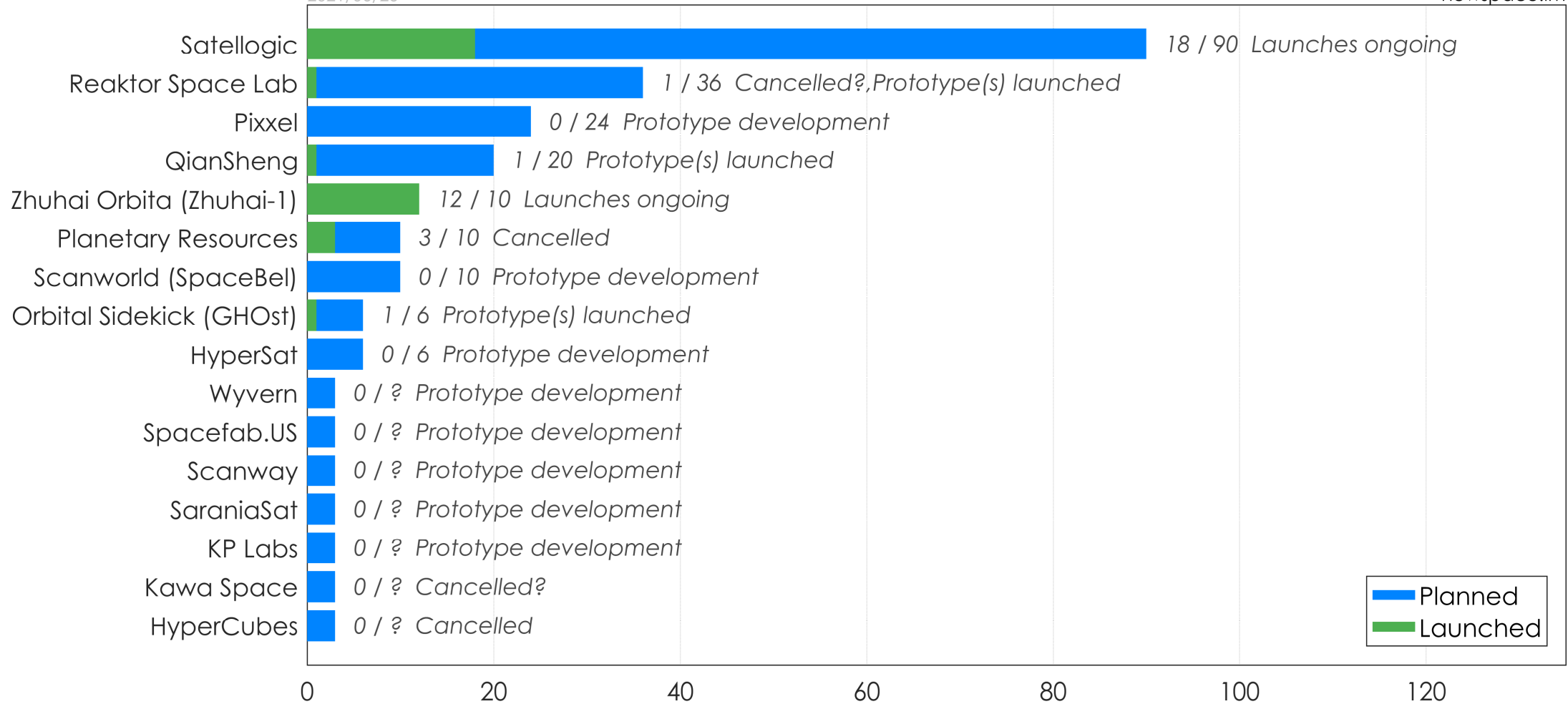
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Hyperspectral Earth Observation Constellations

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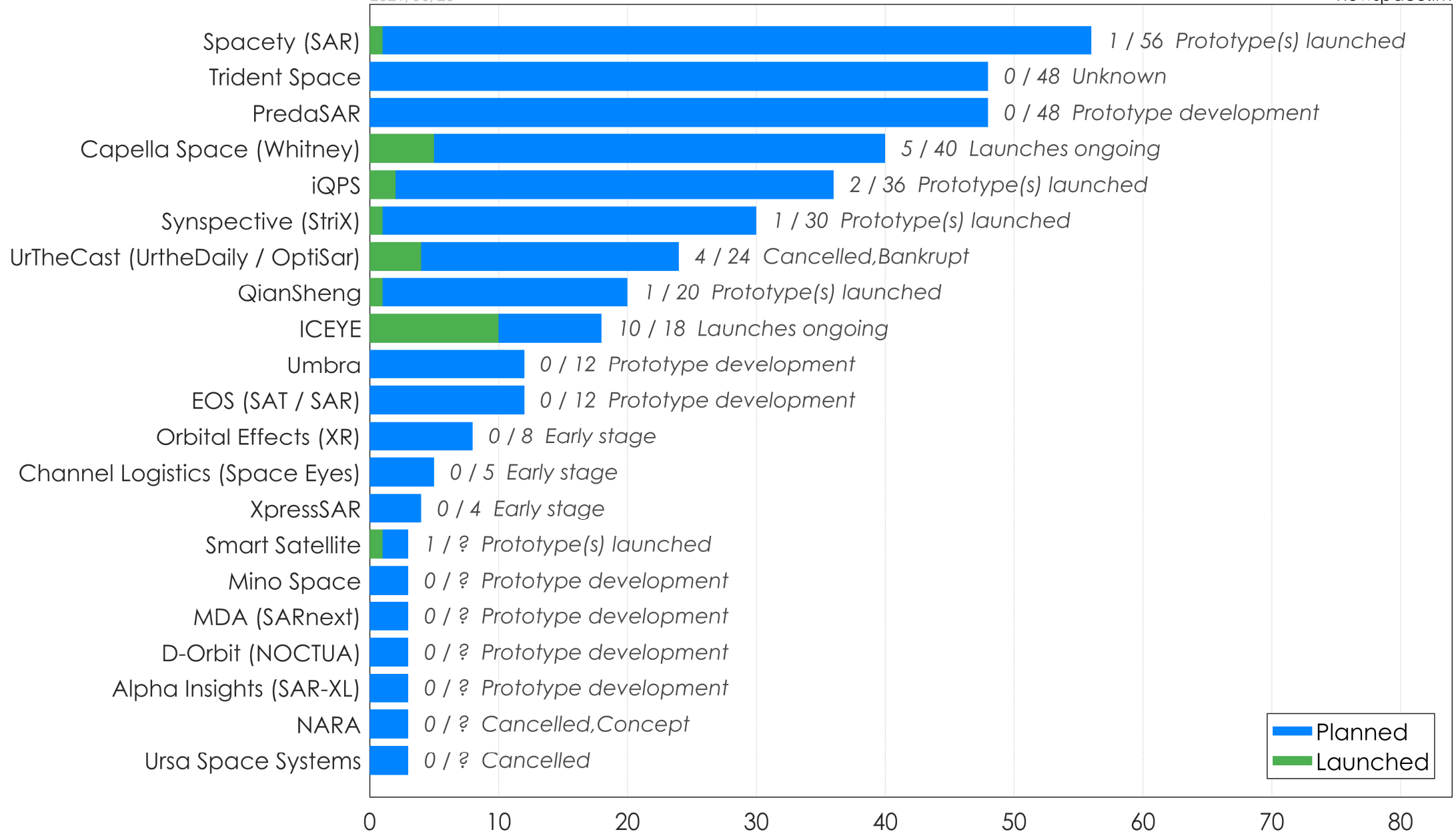
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SAR (Synthetic Aperture Radar) Constellations

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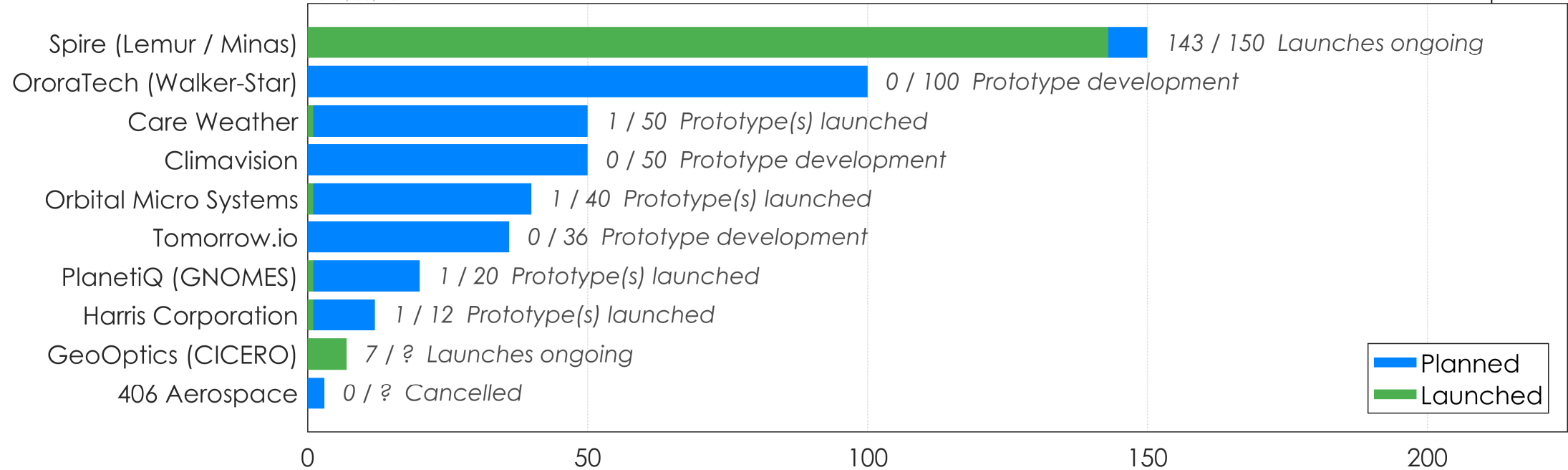
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Weather Constellations

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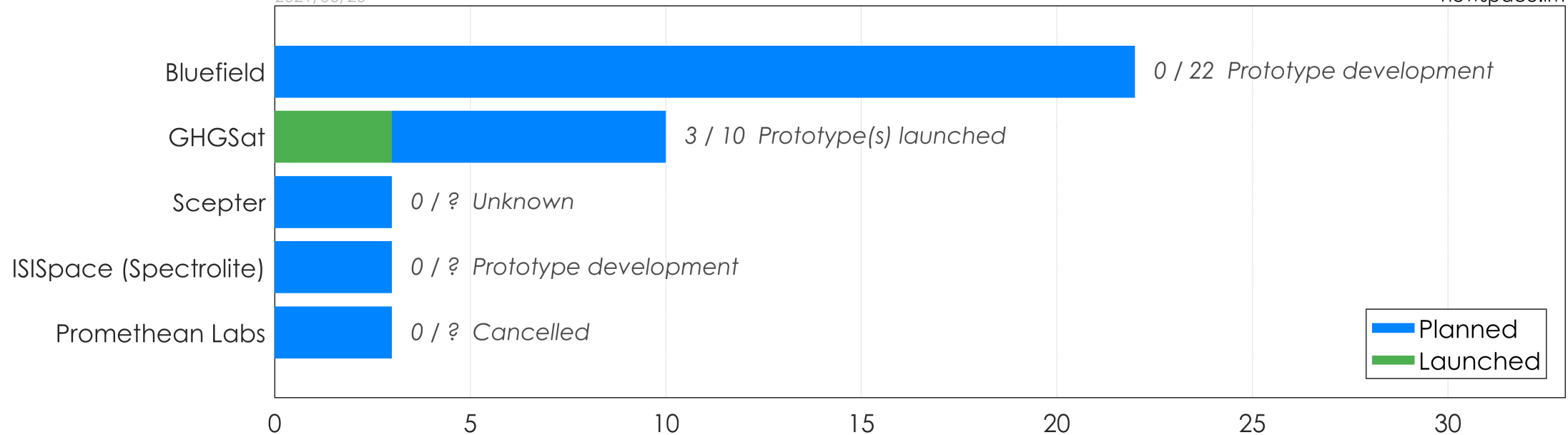
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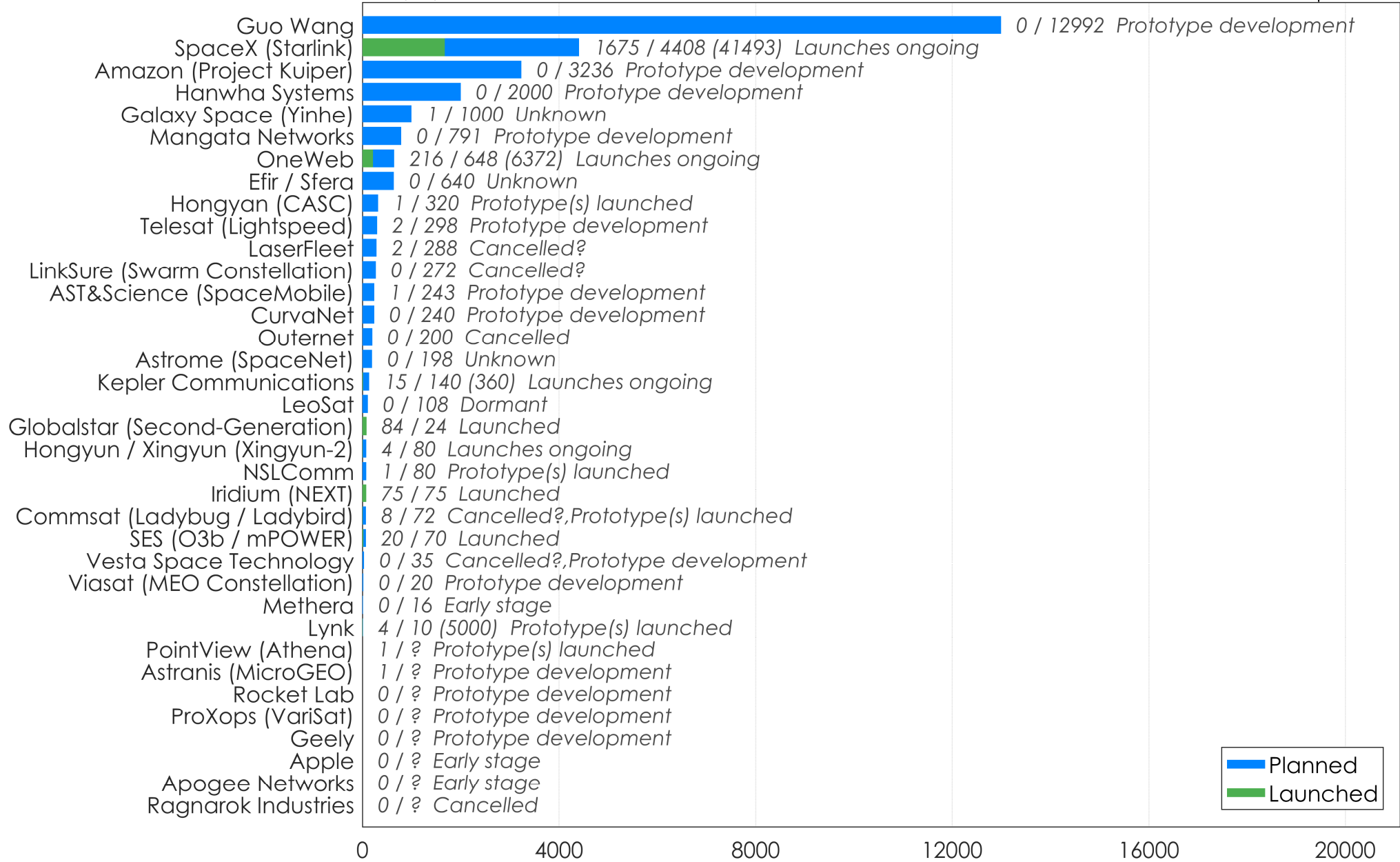
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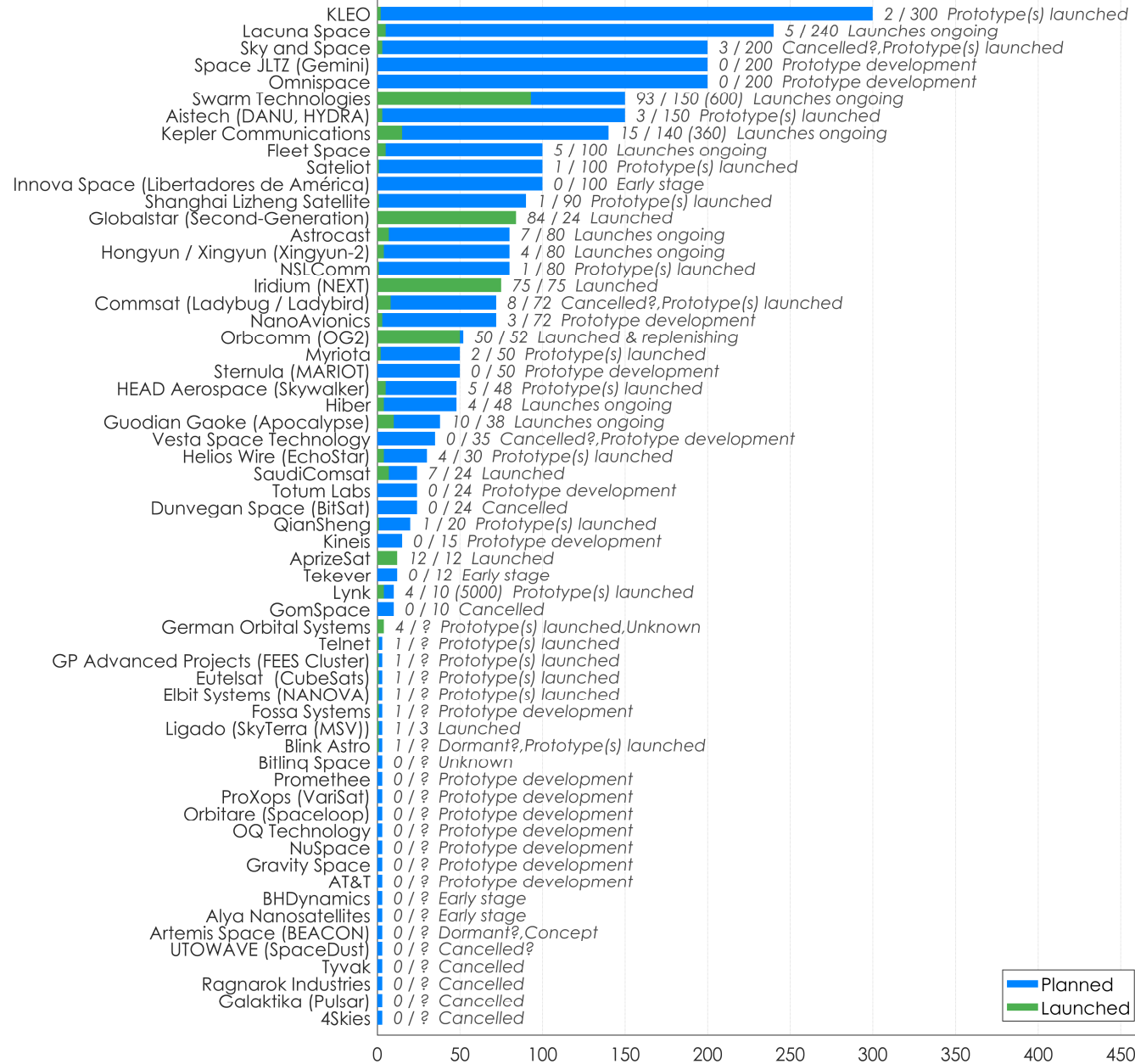
Emissions Monitoring Constellations

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Communications

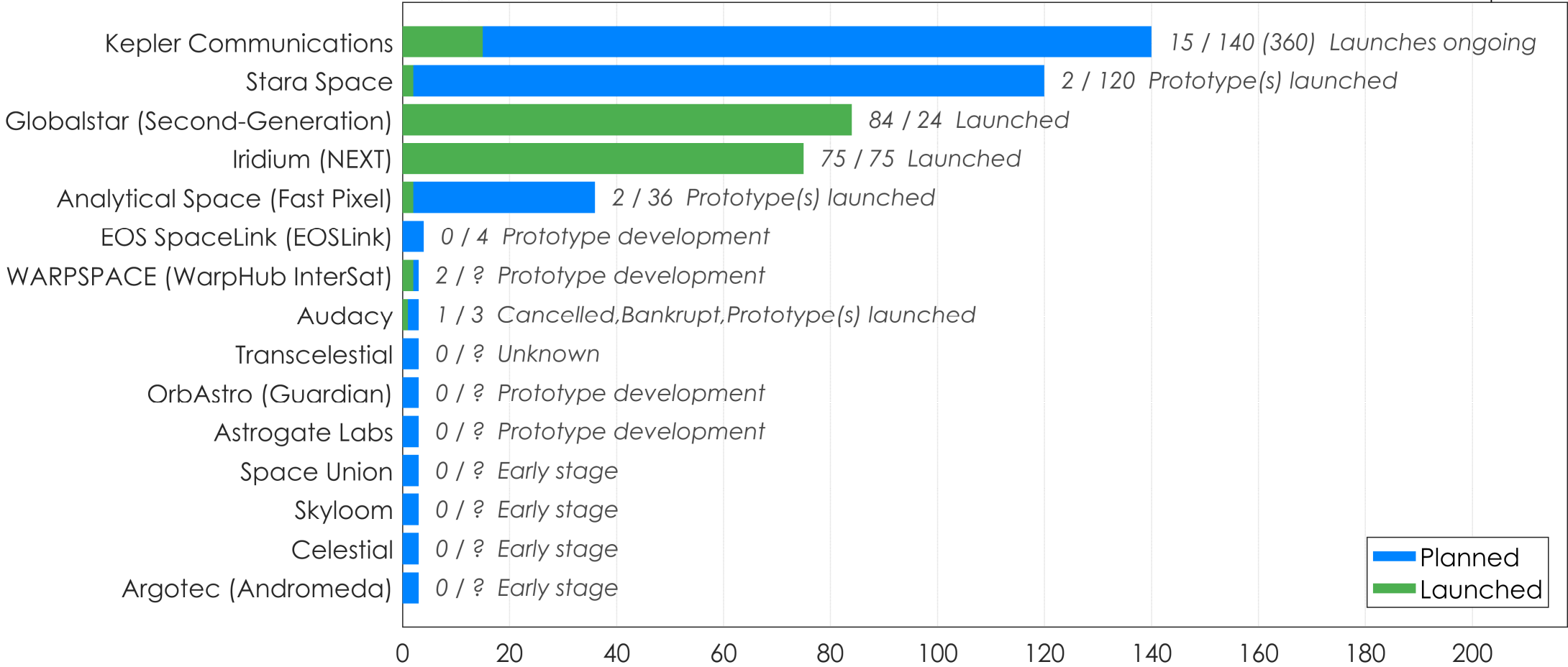


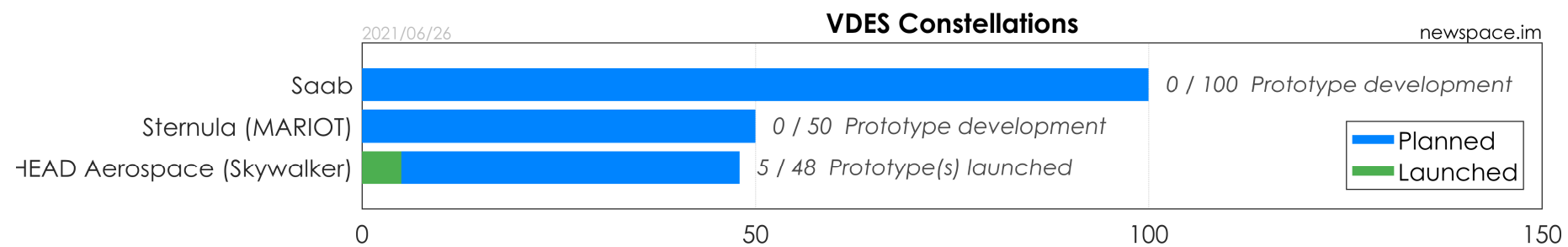
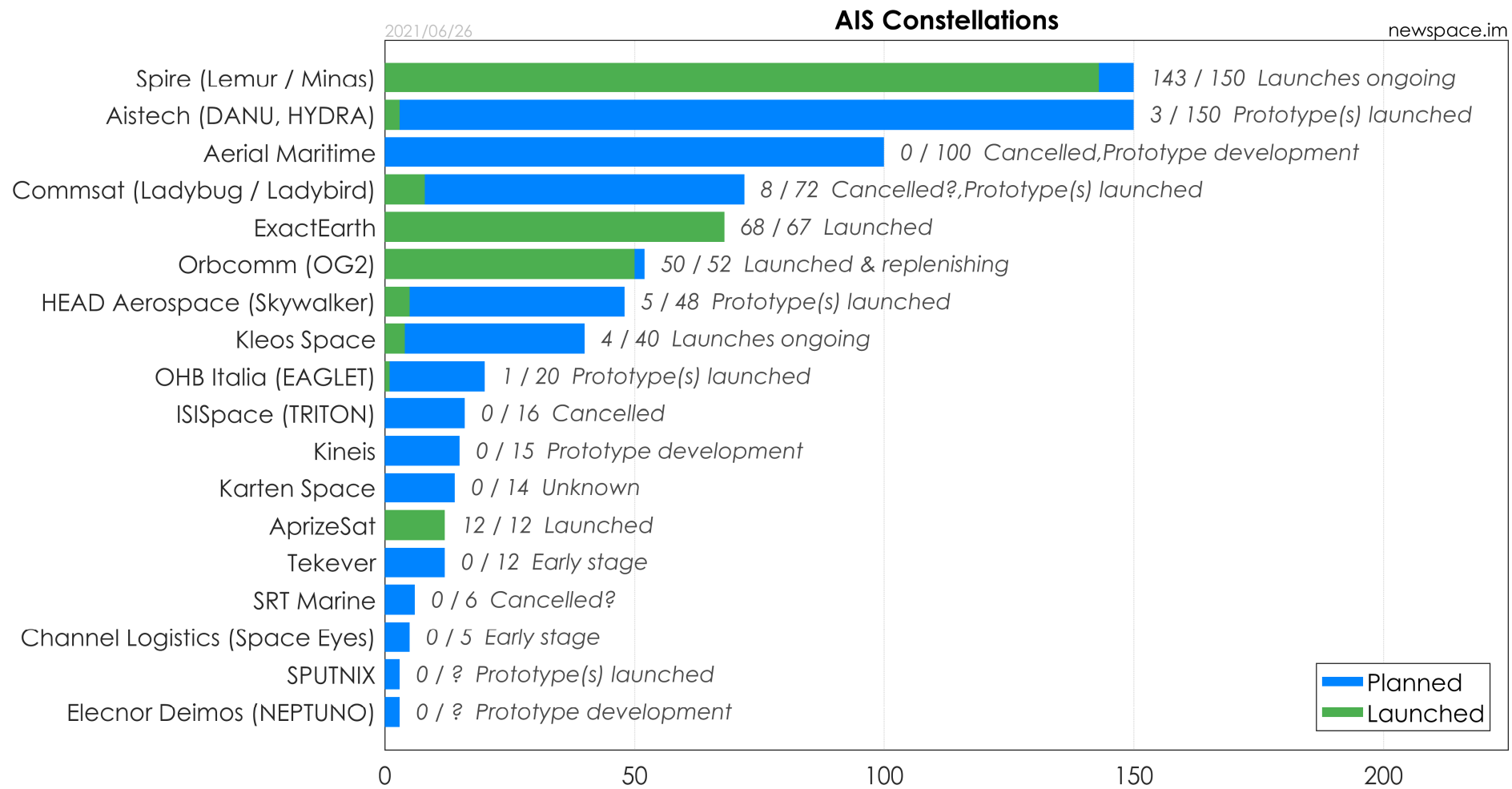


Orbital Data Relay Constellations

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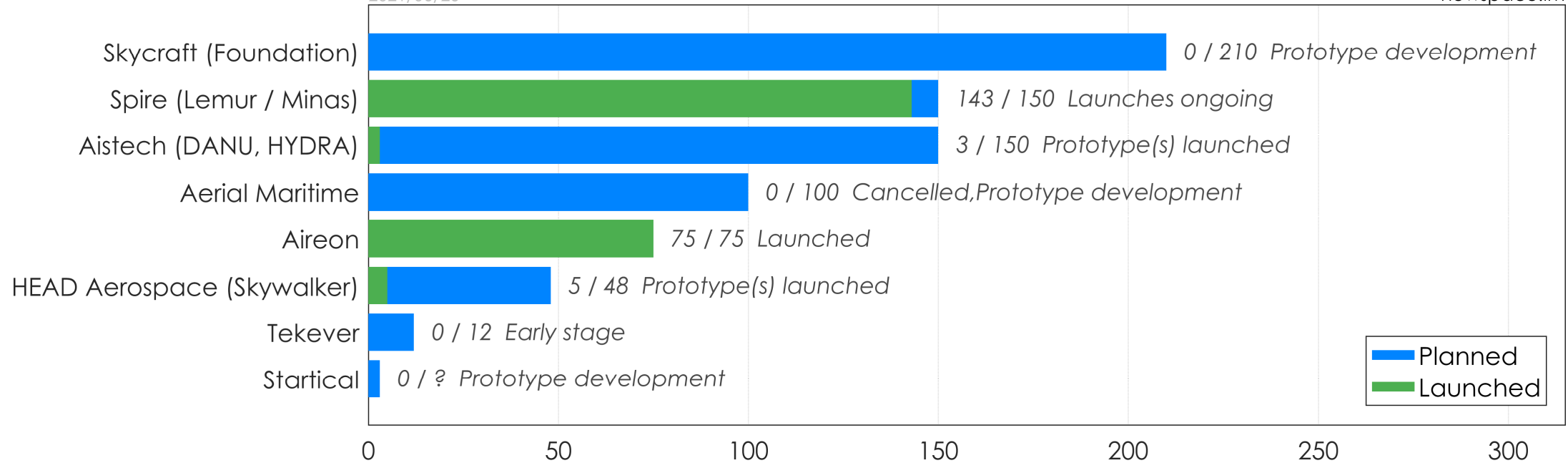




ADS-B Constellations

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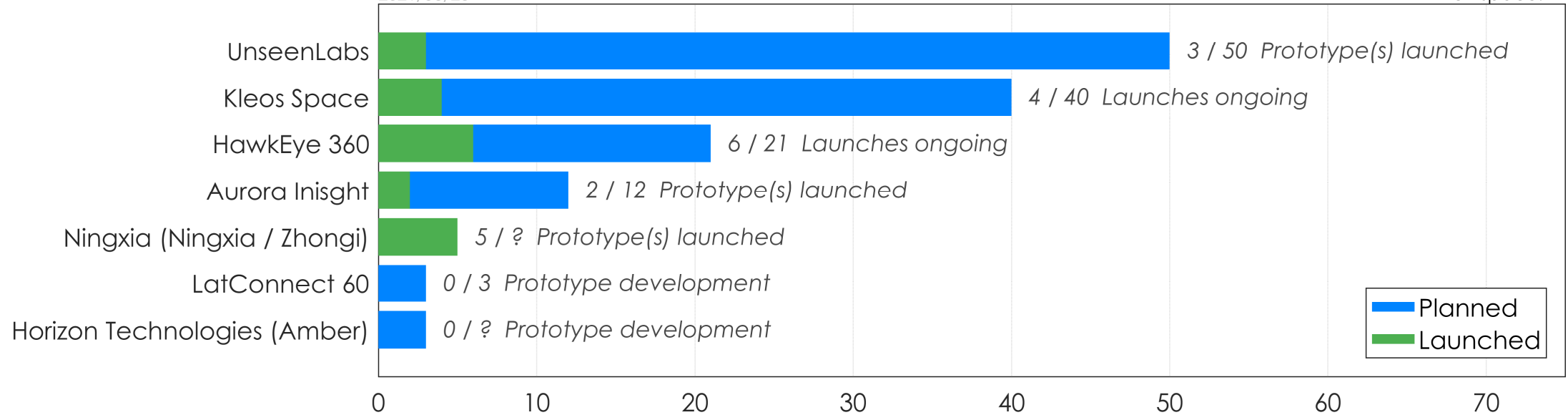
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RF Spectrum Monitoring / Geolocation Constellations

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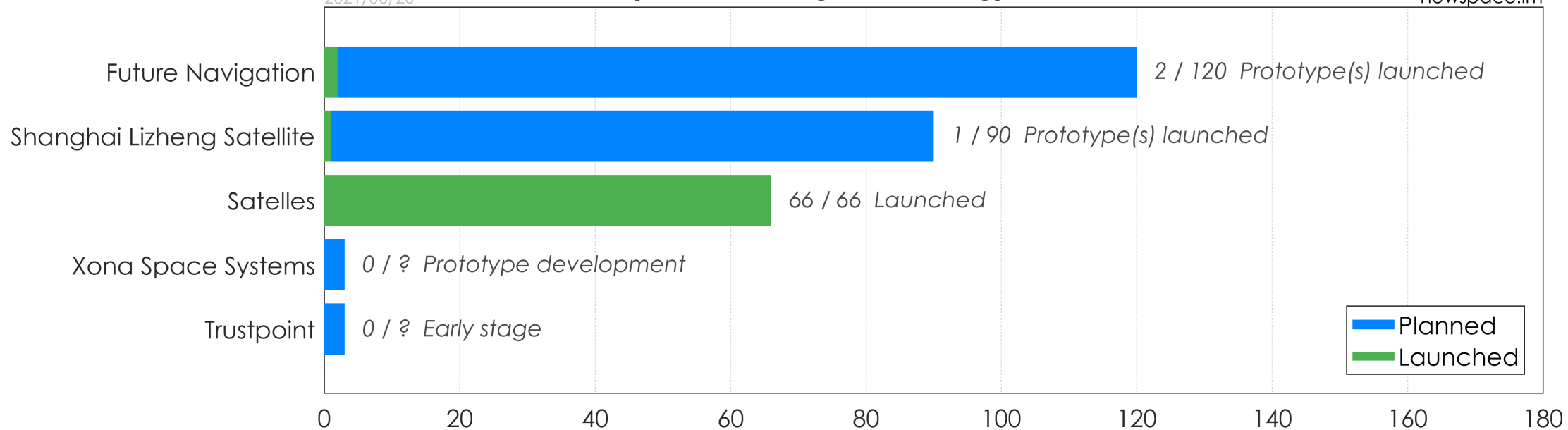
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PNT (Position, Navigation, Timing) / GNSS Constellations

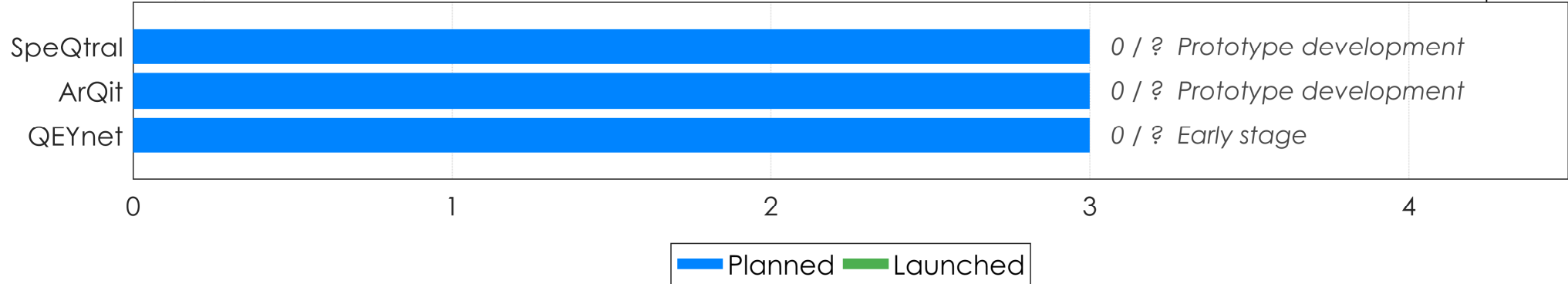
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QKD (Quantum Key Distribution) Constellations

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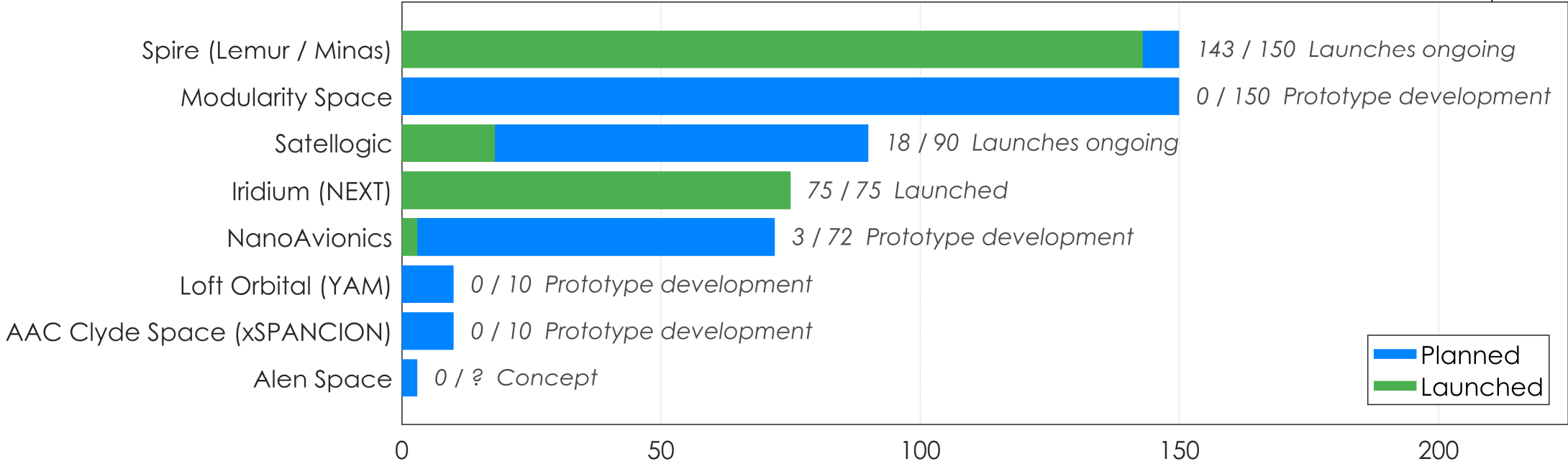


Miscellaneous

Constellation-As-A-Service Constellations

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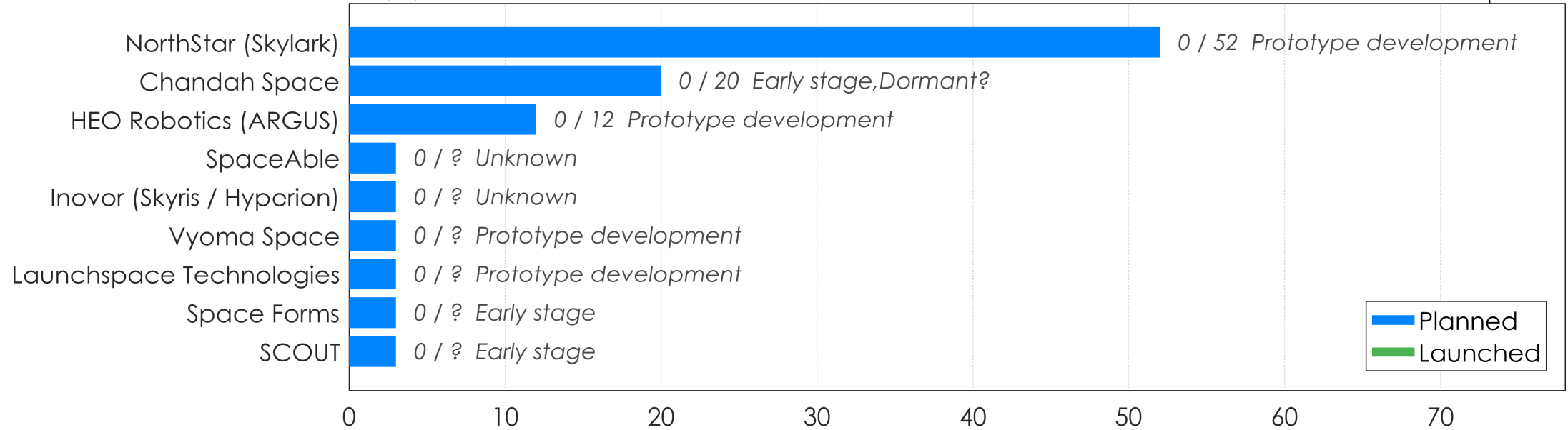
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2021/06/26

SSA (Space Situational Awareness) Constellations

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Conclusions and Future Work

- Statistical overview of 251 commercial satellite constellations was presented in this May 2021 survey.
- Only 4% of the constellations have been fully launched and ~8% are currently being launched.
- Notable amount of additional entities have raised funding and are in active development.
- About 1/3 of constellations are dormant or cancelled and the quantity is expected to increase.
- Broadband Internet are the largest satellite constellations by size and most spacecraft launched.
- Followed by Optical Earth Observation, IoT / M2M, SAR, AIS and Weather. Historically proven fields.
- Latest new trends are Orbital Data Relays, RF Monitoring / Geolocation, Infrared or Hyperspectral EO.
- Emerging applications, and without prior governmental or commercial satellites, are QKD, SSA, GNSS / PNT, VDES, In-orbit Inspection, Constellation-As-A-Service etc.
- In general, most constellations seem slower to take off than planned and expected.

Future work

- Application specific trends and constellation development timelines to be studied in more detail.
- Major open question is the economic sustainability of most if not all of the satellite constellations.
- Sizes of addressable markets – In-house built (and launched) constellations distort market studies.

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Erik Kulu

erik.kulu@nanosats.eu